Optimizing Antimicrobial Stewardship in the Emergency Department

Julia Sapozhnikov, PharmD[a], Fritzie S. Albarillo, MD, BSN[b], Michael S. Pulia, MD, PhD[c,*]

KEYWORDS

• Antimicrobial stewardship • Clinical decision support
• Pharmacists Emergency medicine • Diagnostic stewardship

KEY POINTS

- The emergency department is a unique and essential setting for antimicrobial stewardship initiatives.
- Antimicrobial stewardship is a patient safety (eg, adverse drug reactions) and public health imperative because of rising rates of bacterial resistance.
- Emergency department antibiotic stewardship interventions should take into consideration the work system and target infection-specific factors that drive inappropriate prescribing.
- Education-based stewardship interventions alone rarely result in sustainable behavior change and are not recommended.
- Clinical decision support tools embedded in the electronic health record (eg, antibiotic order sets) and pharmacist-led interventions (eg, culture follow-up and prospective antibiotic review) are the most effective ways to improve antibiotic prescribing in the emergency department.
- Innovative rapid pathogen detection assays and host response biomarkers hold promise for identifying bacterial infection, but there is insufficient evidence currently to designate any of these tests as standard of care.

INTRODUCTION TO ANTIMICROBIAL STEWARDSHIP

Antimicrobial stewardship (AMS), within a health care context, refers to efforts aimed at optimizing antimicrobial utilization. The primary focus of AMS is on antibacterial agents given the well-established causal link between utilization and bacteria

[a] Medical Science Liaison, Karius Inc, 975 Island Drive, Redwood City, CA 94065, USA; [b] Department of Medicine, Infectious Diseases Division, Loyola University Medical Center, Loyola University Medical Center is 2160 South First Avenue, Maywood, IL 60153, USA; [c] BerbeeWalsh Department of Emergency Medicine, University of Wisconsin School of Medicine and Public Health, 800 University Bay Drive, Suite 300, Madison, WI 53705, USA
* Corresponding author.
E-mail address: mspulia@medicine.wisc.edu
Twitter: @DrMichaelPulia (M.S.P.)

Emerg Med Clin N Am 42 (2024) 443–459
https://doi.org/10.1016/j.emc.2024.02.003
emed.theclinics.com
0733-8627/24/© 2024 Elsevier Inc. All rights reserved.

Descargado para Dr Jorge Martel Granados (emergencymedicine.peru@gmail.com) en Pontifical Xavierian University de ClinicalKey.es por Elsevier en mayo 03, 2024. Para uso personal exclusivamente. No se permiten otros usos sin autorización. Copyright ©2024. Elsevier Inc. Todos los derechos reservados.

SHOUT
SHARE
IT

resistance; however, antiviral and antifungal agents are also within the scope of antimicrobial stewardship programs (ASPs). Antimicrobial resistance (AMR) is now a worldwide phenomenon accelerated by the overuse of antibiotics, and is considered a public health threat by the Centers for Disease Control and Prevention (CDC) and the World Health Organization.[1,2] In 2019, resistant bacterial infections were associated with nearly 5 million deaths worldwide, and in the United States, more than 2.8 million AMR-related infections occur annually leading to 35,000 deaths.[3] There is mounting evidence to support that AMS can lead to reduction in antimicrobial use and AMR.[4,5] Highlighting the critical need for AMS, approximately 50% of hospitalized patients receive at least one antibiotic during their hospital stay, and up to 50% of these antibiotics are deemed unnecessary.[6–8]

At a more granular level, the goal of AMS is to identify patients who have bacterial infections requiring treatment, while avoiding treatment in those who do not, to optimize selection of antimicrobials, their dosing and route, and duration of therapy, so as to optimize clinical outcomes while curtailing adverse consequences of antimicrobial exposure.[6] AMS programs have been shown to improve patient safety outcomes including proper evaluation of antibiotic allergies, prevention of kidney injury, and adequate treatment of infections to improve clinical outcomes. Reduction in *Clostridioides difficile* infection (CDI) is another major benefit of effective AMS.[9] Antibiotic use can lead to alteration of the intestinal microbiota leading to disruption of the gut microbiome and overgrowth of pathogenic organisms, such as *C difficile*. CDI is considered a major health threat by the CDC. In 2017, there were 223,900 hospitalized patients secondary to CDI leading to 12,900 deaths, primarily among older adults.[3]

KEY ROLE OF THE EMERGENCY DEPARTMENT IN ANTIMICROBIAL STEWARDSHIP

As recognized by a 2020 policy statement from the American College of Emergency Physicians, AMS is an important quality-of-care imperative in which all emergency providers and emergency departments (ED) should engage.[10] The ED plays a central role in the health care system by serving as a bridge between the ambulatory care, long-term care, and inpatient care settings. In addition to steadily increasing patient volumes, the ED often functions as the de facto setting where acute, undifferentiated patients undergo rapid diagnostic evaluation. A significant portion of acute ambulatory conditions are diagnosed and treated in the ED, patients in long-term care setting are often evaluated in the ED for potential infections, and most unscheduled admissions originate from the ED. As such, the ED is responsible for assigning an initial diagnosis for patients transitioning across health care settings. Correct diagnosis of a bacterial infection is the component of AMS that is furthest upstream, because efforts to optimize antibiotic selection, dose, and duration presume a correct diagnosis was made to justify antibiotic initiation. Failure to properly diagnosis and initiate antibiotic therapy in patients with bacterial infections can result in infection progression and adverse outcomes. Conversely, overuse of antibiotics in patients without true infections can also result in patient harm and worsening AMR at the hospital and community level. Additionally, decisions to initiate antibiotic therapy in the ED result in diagnostic and therapeutic inertia that can result in continuation of unnecessary antibiotics in downstream care settings.[11–13] This highlights the importance of the ED as a key setting for AMS, where diagnostic and management decisions directly impact antibiotic use across the entire health care continuum.

BARRIERS TO ANTIMICROBIAL STEWARDSHIP IN THE EMERGENCY DEPARTMENT

As a work system, the ED presents unique challenges to implementation of quality improvement initiatives and AMS is no exception. ED providers treat patients in a

Descargado para Dr Jorge Martel Granados (emergencymedicine.peru@gmail.com) en Pontifical Xavierian University de ClinicalKey.es por Elsevier en mayo 03, 2024. Para uso personal exclusivamente. No se permiten otros usos sin autorización. Copyright ©2024. Elsevier Inc. Todos los derechos reservados.

crowded, noisy environment, under incredible time pressure while simultaneously engaging in high-risk and high-density decision making with incomplete information. This often necessitates the use of cognitive heuristics that can increase the risk of diagnostic and therapeutic errors. Examples that pertain to ED AMS include attributing vague weakness to a urinary tract infection (UTI) in older adults, failing to recognize an important antibiotic dose adjustment for patients with renal impairment, or initiating antibiotic therapy without recognizing a history of AMR and broadening coverage. It is incumbent on those seeking to implement stewardship in the ED to consider the unique work system elements and ensure that interventions address actual drivers of suboptimal prescribing as characterized in the qualitative and mixed-methods literature. Specific guidance on successful implementation is available from research that characterizes barriers and how to overcome them, using a frontline provider perspective. Common drivers of antibiotic overuse and misuse include diagnostic uncertainty, perceived patient preferences for antibiotics, concern about adverse outcomes, and medicolegal liability.[14–19] Although patient preference is often offered up as a driver by providers, the available literature does not indicate this is a widespread phenomenon nor that overprescribing of antibiotics improves satisfaction.[20,21] Interventions should also be infection specific and thoughtfully integrated into existing ED workflows/care pathways. Lack of knowledge about when to withhold antibiotics and correct antibiotic selection does not seem to be a primary driver, and as such educational interventions alone are unlikely to succeed as an ED-focused intervention.

ROLE OF EMERGENCY PROVIDERS IN ANTIMICROBIAL STEWARDSHIP

Emergency providers make multiple diagnostic and management decisions that impact AMS. In addition to making an initial diagnosis and empiric antibiotic selection, emergency providers are tasked with collecting appropriate microbiologic specimens that allow downstream providers to confirm the presence of a bacterial infection and tailor or de-escalate antibiotic therapy according to isolate susceptibility. Specific recommendations for obtaining infection-specific (eg, urinary, sputum) cultures are covered elsewhere in this issue. Blood cultures should generally be obtained whenever there is a suspicion of bacteremia, a working diagnosis of sepsis, critical illness related to suspected infection, and immunocompromised status. Blood cultures should also be strongly considered when initiating broad-spectrum antibiotic therapy, to promote and facilitate downstream antibiotic de-escalation.

Beyond ED patient care, emergency providers should participate in AMS intervention design and implementation, at the ED and institutional level. For example, this includes representation on the hospital AMS and sepsis committees. An ED AMS champion would ideally have protected nonclinical time to participate in quality improvement initiatives, committee work, and the design and implementation ED-specific AMS interventions. Informatics support for this role is also critical because it generally involves generating metrics from electronic health record data and benchmarking prescribing patterns to enable audit and feedback activities aimed at improving antibiotic prescribing by outlier providers.

ROLE OF INFECTIOUS DISEASE PHYSICIANS IN EMERGENCY DEPARTMENT ANTIBIOTIC STEWARDSHIP

In conjunction with an ED AMS champion, infectious diseases (ID) physicians can help guide ED AMS activities and improve success. The literature highlights the following potential roles for the ID specialist: timely ID consultation in the ED, development of guidelines and treatment algorithms, evaluating antimicrobial prescriptions to assess

Descargado para Dr Jorge Martel Granados (emergencymedicine.peru@gmail.com) en Pontifical Xavierian University de ClinicalKey.es por Elsevier en mayo 03, 2024. Para uso personal exclusivamente. No se permiten otros usos sin autorización. Copyright ©2024. Elsevier Inc. Todos los derechos reservados.

for compliance with local guidelines, providing audit and feedback intervention, and education. Dinh and colleagues performed a quasiexperimental study following implementation of a dedicated ID physician (0.2 full-time equivalent) in the ED of a tertiary university hospital in France.[8,22–25] The ID physician reviewed and provided feedback on antimicrobial prescriptions, developed treatment guidelines, provided educational courses, and reviewed microbiology data. The study showed significant decreases in overall and guideline-discordant antimicrobial prescribing.[24]

EMERGENCY DEPARTMENT PHARMACISTS AND BEDSIDE ANTIBIOTIC STEWARDSHIP

The role of a pharmacist within the ED has expanded over time to include the provision of comprehensive clinical services.[26] The presence of an ED clinical pharmacists is increasing and is often considered an integral component of multidisciplinary ED practice.[27] ED pharmacists are uniquely positioned to be able to impact antimicrobial prescribing from various angles. Evidence-based AMS interventions include spectrum assessment, optimizing time to antibiotic administration, allergy assessment, and dose optimization.

ED clinical pharmacists can assist providers in antibiotic selection based on a variety of factors. They have knowledge of the spectrum of activity of antimicrobials, drug formulations, dosing, and drug-interactions, allowing them to ensure that the right antibiotics are ordered on the right patient. ED pharmacists can perform activities that busy ED providers may not, such as reviewing a patient's electronic health record for previous microbiologic results or antimicrobial history to evaluate risk factors for resistance organisms. Clinical pharmacists are able to serve as a physician extender by reviewing microbiologic culture data in real time and proactively communicating with providers to assist with decision making regarding the spectrum of antibiotic regimens.[28–30] ED pharmacist may also take into consideration clinical acuity, source of infection, renal function, and local susceptibilities patterns.[31] Studies have demonstrated the impact that pharmacists have had on improving initial antimicrobial selection, streamlining, and resolving bug-drug mismatches in the ED.[32–34] Improved outcomes have been shown across various indications and infectious syndromes including sepsis, pneumonia, intra-abdominal infections (IAIs), UTIs, and trauma/fracture prophylaxis.[28,33,35–39] A recent study of ED patients with community-acquired pneumonia (CAP) and IAI found that just the presence of a pharmacist significantly increased guideline-concordant antibiotic prescribing in ED and subsequent inpatient orders.[35] Similarly, a systematic review and meta-analysis of 24 studies demonstrated that appropriate prescribing of antibiotics was more likely with pharmacist intervention, particularly in patients with pneumonia and UTI (odds ratio, 3.47; 95% confidence interval, 2.39–5.03).[40]

Early and appropriate antimicrobial administration is associated with improved clinical outcomes in patients with sepsis and is a recommended practice by the Surviving Sepsis Campaign.[41] The involvement of an ED pharmacist has been shown to reduce time to antimicrobial administration in patients presenting with sepsis.,[33,42] with one study showing a median 16-minute reduction in time to antibiotic administration.[33] Prospective verification of intravenous antibiotics by an ED pharmacist can also reduce time to appropriate antibiotic therapy in noncritically ill patients, including pneumonia, UTI, skin and soft tissue infections, and IAI.[43] In addition, ED pharmacists may impact time to administration by admixing antibiotics, priming lines, programming medication pumps, and facilitating rapid delivery of medications not stocked in the ED, as needed.[42] ED pharmacists are also available for bedside questions, such as compatibility with lines or other medications.

Descargado para Dr Jorge Martel Granados (emergencymedicine.peru@gmail.com) en Pontifical Xavierian University de ClinicalKey.es por Elsevier en mayo 03, 2024. Para uso personal exclusivamente. No se permiten otros usos sin autorización. Copyright ©2024. Elsevier Inc. Todos los derechos reservados.

The ED pharmacists' role can also include conducting allergy assessments, a critical AMS activity. Patients labeled with β-lactam allergy receive more costly, toxic, broad-spectrum, and, at times, less effective antibiotics.[44] The ED is an ideal place to assess allergies because it is often the first point of contact for hospitalized patients. Pharmacists have the knowledge, skills, and time to be able to perform an allergy assessment. A retrospective, quasiexperimental study of 380 patients showed that a pharmacist-led penicillin allergy assessment and interview increased the use of guideline-concordant antibiotics and decreased the use of fluoroquinolones in the ED setting.[44] Further studies should investigate novel strategies involving ED pharmacists to improve allergy assessment, such as participation in allergy delabeling.[45]

One of the most common activities that ED pharmacists participate in is providing dosing recommendations for empiric antibiotics.[36] Dose optimization in the ED is challenging, because host factors impacting pharmacokinetic and pharmacodynamic properties are not known. When selecting an antimicrobial and dosing regimen, in addition to age and weight, pharmacists evaluate renal and hepatic clearance, site of infection, other concomitant medications, and properties of the antimicrobial.[46] Furthermore, patients with sepsis may have various pharmacokinetic derangements that impact dosing including altered protein binding, volume of distribution, renal clearance, and oral absorption. Clinical pharmacists are best equipped to consider all these factors. DeWitt and coworkers[47] demonstrated that antibiotic orders were more likely to have appropriate doses when the ED pharmacist was present (95% vs 74%; odds ratio, 6.9; 95% confidence interval, 2.5–18.8), and this impact was even more profound in patients with renal impairment. Many ED order sets have the option to place an antibiotic order as "pharmacist to dose," allowing pharmacists to make dosing decisions independently.[28]

Lastly, ED pharmacists can conduct patient and health care provider education.[48] ED pharmacists can counsel patients on new medications, including antimicrobials.[49] Information might include the purpose of the medication and expected benefits, proper administration, common side effects, monitoring parameters, potential drug-drug interactions, and warnings or precautions to be aware of. ED pharmacists routinely provide antimicrobial-related education to nursing staff, including sequence of infusions and commonly encountered side effects.[36]

INFECTIOUS DISEASE PHARMACISTS AND EMERGENCY DEPARTMENT ANTIBIOTIC STEWARDSHIP PROGRAMS

High ED staff turnover rates, rotating schedules, and crowding are just some of the barriers to sustained system-based AMS in the ED.[30] Although ID clinical pharmacists traditionally spend their time on inpatient interventions, there is a growing focus on AMS efforts that occur in the ED and outpatient setting and during transitions of care. In their call to action, May and colleagues[46] outline several strategies that can be implemented in the ED. Examples of resources that can help ED providers in making antimicrobial-related decisions include clinical guidelines/pathways, order sets[50,51] and other clinical decision support systems (CDSS), formulary restrictions, education, and ED-specific antibiograms. CDSS are discussed further later. ID pharmacists can play an integral part in the development and implementation of these types of AMS activities in the ED.

ID pharmacists collaborate with microbiology departments to create antibiograms for the inpatient and outpatient settings. Because the ED lies at the intersection between the two, institutions may create ED-specific antibiograms to more accurately reflect the susceptibility patterns in this heterogeneous population.[52,53] Resistance

Descargado para Dr Jorge Martel Granados (emergencymedicine.peru@gmail.com) en Pontifical Xavierian University de ClinicalKey.es por Elsevier en mayo 03, 2024. Para uso personal exclusivamente. No se permiten otros usos sin autorización. Copyright ©2024. Elsevier Inc. Todos los derechos reservados.

patterns in isolates from ED patients may vary significantly from that of hospitalized patients, particularly for UTIs, and this information has been used to improve ED antimicrobial utilization.[52–58] ED-specific antibiograms should be incorporated into CDSS platforms to assist providers at the point of clinical decision-making.[46]

ID pharmacists are usually involved in developing empiric therapy guidelines or clinical pathway and can tailor guidelines and pathways to specific units, such as the ED, by considering ED-specific susceptibility data and patient populations. Incorporating guideline-concordant recommendations into the electronic health record can aid ED providers in ordering first-line antimicrobials more readily.[8] Order sets and clinical pathways can be integrated in CDSS platforms to aid providers during decision-making. For example, best practice alerts may appear when restricted antimicrobials are ordered or when new microbiologic results are available.[30] These types of interventions have been studied for multiple infection types. A multicenter prospective preintervention/postintervention study of UTIs in the ED found that incorporating recommendations in CDSS platforms improved antibiotic selection.[59] CDSS strategies have been shown to reduce antimicrobial prescriptions for acute bronchitis by 14%.[60] A study of ED patients with CAP demonstrated feasibility and potential benefit of real-time CDSS in aiding physicians' antimicrobial prescribing in this population.[61] ID pharmacists may be involved in sepsis committees, contributing to the standardization of order sets to increase appropriateness and decrease time to antibiotics related to sepsis care. To sustain success, they should seek to avoid alert fatigue and information overload. Ultimately, guideline creation and CDSS implementation should be multidisciplinary, involving ID pharmacists and ED stakeholders.[30]

ID pharmacists are well positioned to lead AMS education efforts, although these are not recommended as a stand-alone intervention, and are best combined with other AMS interventions.[62] Common education strategies include prospective audit and feedback, seminars, grand rounds, academic detailing, peer comparison, and learning modules.[27,62] ID pharmacists can collaborate with an ED champion to facilitate education for new-hires and staff annually on various AMS updates including local resistance patterns, new clinical guidelines, or quality improvement initiatives. Continued education of staff promotes dialogue and increases visibility of AMS efforts in the ED setting.[30] Multifaceted approaches in the ED (ie, clinical guidelines in combination with behavioral interventions) have been effective for a variety of infection types, including pharyngitis, asymptomatic bacteriuria, and UTIs.[8,63–65] One study showed guideline-adherent treatment of CAP, skin and soft tissue infections, and UTIs was increased with pharmacist-driven implementation of integrated clinical algorithms.[66] To improve successful uptake of any ED-focused AMS initiatives, ID pharmacists should include ED stakeholders at all stages of implementation.

CLINICAL DECISION SUPPORT SYSTEMS TO IMPROVE EMERGENCY DEPARTMENT STEWARDSHIP

CDSS are electronic tools that receive data, such as medication orders and administration, and microbiology results from the electronic health record. CDSS provide opportunities for clinicians to streamline AMS interventions. They are recommended by the 2016 Infectious Disease Society of America and Society for Healthcare Epidemiology of America as a tool in improving antimicrobial prescribing.[67,68] Several studies have shown that use of CDSS in the ED has led to decrease in antimicrobial use, improving empiric antibiotic selection,[69] and compliance to guidelines.[59] Using a CDSS, real-time alerts can be customized to aid clinicians in streamlining antimicrobial

Descargado para Dr Jorge Martel Granados (emergencymedicine.peru@gmail.com) en Pontifical Xavierian University de ClinicalKey.es por Elsevier en mayo 03, 2024. Para uso personal exclusivamente. No se permiten otros usos sin autorización. Copyright ©2024. Elsevier Inc. Todos los derechos reservados.

therapy, such as drug-bug mismatch, double anaerobic coverage, and identification of multidrug-resistant organisms.[68] Monitoring and tracking antimicrobial usage, and susceptibility patterns of organisms via antibiograms can also be developed through CDSS.[68] Hajesmaeel-Gohari and colleagues[70] reviewed 11 publications evaluating the utility of Computerized Physician Order Entry and CDSS in decreasing adverse drug events in the ED. The authors found that with the use of these tools, there is significant reduction in the rates of erroneous prescriptions/doses, excessive doses, adverse drug events, and inappropriate prescription.[70]

DIAGNOSTIC STEWARDSHIP THROUGH ADVANCES IN INFECTIOUS DISEASE DIAGNOSTICS

Diagnostic stewardship (DS), as applied to ID, is considered a synergistic adjunct to AMS.[71,72] The triple aim of DS has been described as "ordering the right test, for the right patient, at the right time."[73] This is achieved by improving the ordering, performing, and reporting of diagnostic tests to increase the likelihood that the provider will reach the correct diagnosis.[71,74] As previously discussed, accurate identification of bacterial infection is the first step of AMS, one that often occurs in the ED. Rapid expansion of the ID diagnostic options available to emergency providers highlights how critical DS is to overall AMS efforts. This must include balancing considerations, such as sample collection feasibility, turnaround times, diagnostic performance, clinical impact, and cost/benefit ratios. Here we discuss some of the recent advances in ID diagnostics from an AMS/DS lens.

Rapid Pathogen Detection

Because of the fast-paced nature of the ED, rapid diagnostic tools are essential to provide prompt and appropriate interventions for patients. Numerous rapid diagnostic tools have been developed and implemented mostly for inpatient use, but their utility in the ED is promising because of their rapid turnaround time for detection of pathogens, which can improve prompt initiation of therapy and de-escalation of unnecessary broad-spectrum therapy, or discontinuation of antibiotics altogether.

Upper respiratory tract infections are one of the leading causes of ED visits. Although almost entirely caused by viruses, up to 52% of these patients receive antibiotics. In pharyngitis, group A streptococcus, which accounts for only 5% to 15% of cases, is the only indication for antibiotics.[75,76] There are several studies demonstrating improved diagnostic accuracy for group A streptococcus using rapid antigen detection test or polymerase chain reaction (PCR).[77–79]

Lower respiratory tract infections (LTRIs), including acute bronchitis and CAP, are among the most common ED diagnoses. Bronchitis is generally considered to be viral by definition and even CAP is more commonly caused by viruses than bacteria.[80,81] The overuse of antibiotics in LTRI is typically caused by the challenges distinguishing between bacterial and viral causes. Rapid urine antigen testing for detection of *Streptococcus pneumoniae* and *Legionella pneumophila* have specificity rates of 98% and 97.1%, respectively, and stand to improve antibiotic prescribing.[82] However, a recent systematic review reported the portion of bacterial CAP cases caused by *S pneumoniae* as between 33% and 50%, whereas *Legionella* was much less common at 3% to 8%.[83] Real-time PCR-based assays for detection of influenza A/B and respiratory syncytial virus from nasopharyngeal swabs also have high specificity rates of 97.9% and 97%,[82] respectively, which improve antibiotic prescribing.[84,85]

Multiplex PCR assays can detect multiple respiratory pathogens from a single specimen, with rapid turnaround times. An example is the original BioFire FilmArray

Descargado para Dr Jorge Martel Granados (emergencymedicine.peru@gmail.com) en Pontifical Xavierian University de ClinicalKey.es por Elsevier en mayo 03, 2024. Para uso personal exclusivamente. No se permiten otros usos sin autorización. Copyright ©2024. Elsevier Inc. Todos los derechos reservados.

respiratory panel, Food and Drug Administration (FDA)-approved in May 2011, which can detect 15 respiratory viruses within approximately 1 hour. Rappo and colleagues[86] evaluated the use of this assay in the ED of a tertiary care center. Compared with usual care with standard microbiologic process, respiratory panel lead to decreased time to diagnosis of viral causes including influenza, and was associated with significantly lower odds ratios for hospitalization, length of stay, duration of antimicrobial utilization, and number chest radiographs.[86] In 2017, the panel was expanded to detect a total of 21 pathogens (17 viruses and 4 bacteria) with shorter turnaround time of 45 minutes. In October 2020, the FDA issued an Emergency Use Authorization for BioFire RP2.1-EZ Panel that included detection of SARS-CoV-2.

The FilmArray Pneumonia panel (PNA panel) is a multiplex PCR test that detects 18 bacterial targets, 8 viral targets, and 7 AMR genes. It requires a high-quality sputum sample or lower respiratory tract specimen (from bronchoscopy) and has a turnaround time of about 1 hour. For 15 of the bacterial targets, the test provides a semiquantitative result that may distinguish colonization versus true infection. Buchan and colleagues[87] evaluated the use of the PNA panel in 259 adult patients admitted with LTRIs, for its diagnostic test characteristics and potential impact on AMS. The panel showed positive percent agreement and negative percent agreement values of 96.2% and 98.1%, respectively, when compared with routine bacterial sputum cultures.[87] Furthermore, the authors concluded that with the use of this panel, there is potential for antibiotic streamlining in 70.7% of cases, with de-escalation or discontinuation of antibiotics in 48.2% of cases.[87]

Rapid PCR-based tests capable of detecting multiple pathogens have also been developed to facilitate diagnosis of infectious diarrhea, abscess pathogen (ie, methicillin-resistant *Staphylococcus aureus*),[88] and central nervous system infections. Examples include gastrointestinal panel and meningitis/encephalitis panel. Beal and colleagues[89] compared the utility of gastrointestinal panel with conventional stool culture. The gastrointestinal panel detected a broader range of pathogens than conventional stool culture, decreased need for imaging studies, reduced need for antibiotics, and resulted in a shorter length of stay.[89] The use of the meningitis/encephalitis panel in 79 ED patients with suspected central nervous system infection was evaluated by Ena and colleagues.[90] Although 58% of patients had clinical and cerebrospinal fluid findings concerning for central nervous system infection, only 30% had an infection confirmed by cerebrospinal fluid culture. The time difference between meningitis/encephalitis panel and cerebrospinal fluid culture results was 3.2 days and meningitis/encephalitis panel results led to antimicrobial adjustments in 59% of patients.[90]

Host Response Biomarkers

The ability to rapidly identify which patients have bacterial infections as opposed to viral or infectious mimics, remains a significant diagnostic challenge for emergency providers. Signs and symptoms of infectious and noninfectious substantially overlap, which can lead to inappropriate antibiotic use. Traditional host response biomarkers, such as leukocyte count and C-reactive protein, in isolation, lack sufficient discriminatory performance for viral versus bacterial infection to definitively guide antibiotic prescribing. Procalcitonin is FDA approved to help providers differentiate viral from bacterial LRTI; however, the most recent American Thoracic Society/Infectious Diseases Society of America CAP guideline does not recommend use of procalcitonin plus clinical judgment to guide initiation of antibiotics for CAP. This recommendation was driven by one large study demonstrating negative initial procalcitonin values in inpatients with subsequently confirmed bacterial CAP.[91,92] However, a recently

Descargado para Dr Jorge Martel Granados (emergencymedicine.peru@gmail.com) en Pontifical Xavierian University de ClinicalKey.es por Elsevier en mayo 03, 2024. Para uso personal exclusivamente. No se permiten otros usos sin autorización. Copyright ©2024. Elsevier Inc. Todos los derechos reservados.

published Infectious Diseases Society of America CAP clinical pathway recommends the use of procalcitonin in the context of hospital AMS guidelines.[93] Although procalcitonin should not be used for all patients with CAP, whether or not it can be successfully used to guide antibiotic initiation in specific clinical scenarios, such as healthy, low-acuity patients with a questionable pulmonary infiltrate on chest radiograph or those with confirmed viral CAP, is a matter of ongoing debate and inquiry.[94,95] A variety of next-generation host response biomarkers are being developed with the goal of improving rapid identification of true bacterial infections, including in the setting of sepsis.[96–99] Although data on the diagnostic performance and potential management impact are promising, there is not yet clinical effectiveness data to support their adoption. We anticipate this will change in the coming years and that one or more of these assays will be incorporated into best practice guidelines for ID diagnosis in the ED.

Diagnostic Stewardship for Urine Testing

Appropriate urine testing is a core AMS focus of DS because accurate UTI diagnosis involves several significant challenges. It is particularly challenging to assess patients with impaired ability to provide a history (eg, cognitive impairment, delirium) and there tends to be an overreliance on urinalysis (UA), a test that has a high false-positive rate.[100] DS around UA and urine culture test ordering and results interpretation thus stands to reduce overdiagnosis and subsequent overtreatment of UTI.[74] Most urine cultures should be ordered for patients with symptoms. Symptomatic UTI must first be distinguished from sexually transmitted infections, overactive bladder, and other conditions, which can mimic certain symptoms.[71] Provider education has been reported to reduce the number of urine cultures, although education alone may not change prescribing behavior.[101] Other so-called preanalytic strategies to reduce culture ordering, and thus overdiagnosis, include requiring an indication to place a urine culture order or holding cultures for processing until requested.[74,102] Another successful preanalytic strategy that has been described is to remove prechecked UA and urine culture orders from order sets, particularly for abdominal pain and psychiatric conditions.[103,104] DS analytical strategies take place at the point of test performance, typically in the laboratory. For UTI diagnosis, an analytical strategy is limiting "reflex" urine cultures to those meeting criteria for pyuria.[105] Postanalytic strategies for UTI DS include suppression or modification of culture results reporting, inclusion of help text to facilitate interpretation of contaminated cultures/skin flora, or incorporating evidence-based guideline recommendations in CDSS triggered at the time of UA and/or urine culture order placement.[59,106,107] These strategies should be considered, piloted, and refined by ED pharmacists to reduce overdiagnosis of UTIs or other infections and ultimately improve antimicrobial use.

Culture Follow-Up Optimization

About a one-third of all antimicrobials prescribed in the outpatient or ED setting are considered inappropriate, according to an estimation by the CDC.[108] Part of antibiotic stewardship in the ED should include appropriate follow-up once cultures and other diagnostic test results have returned. Failure to follow up on culture results can result in delays in appropriate treatment, antibiotic overuse, and poor clinical outcomes.[109] Yet successful culture follow-up (CFU) is challenging in the ED given the intermittent nature of providers' shifts and is often fraught with inconsistent management and documentation.[109] Formal CFU programs have been described, and represent yet another way to successfully expand AMS efforts into the ED settings and bridge transitions of care.[110] CFU programs most commonly focus on urine cultures, but also are used for follow-up on testing involving sexually transmitted infections,

Descargado para Dr Jorge Martel Granados (emergencymedicine.peru@gmail.com) en Pontifical Xavierian University de ClinicalKey.es por Elsevier en mayo 03, 2024. Para uso personal exclusivamente. No se permiten otros usos sin autorización. Copyright ©2024. Elsevier Inc. Todos los derechos reservados.

skin and soft tissue infections, bloodstream infections, and respiratory tract infections.[31,111] Physicians, ED pharmacists, and advanced practice providers all have the skills and knowledge required to perform CFU duties.[110,112] ED pharmacist-led CFU programs have been shown to decrease ED visits and admissions, treatment failure rates, and time to patient contact, and increase appropriateness of antimicrobial regimens in various studies.[48,110,113–115] For example, in one study of 180 ED urine cultures an ED pharmacist doing CFU identified inappropriate treatment in 23% of cases, with successful intervention in 83% of these.[38] A large health system of 13 EDs published their experience with a pharmacist-driven CFU program where approximately 40% of patients discharged with cultures pending required intervention (most often initiation of antibiotic therapy).[109] There is also published data on the positive impact of adding a clinical ED pharmacist to advanced practice providers- and physician-led CFU programs, particularly in terms of improving antibiotic selection, dose, and duration.[110,114,116,117] These innovative partnerships improve antimicrobial prescribing in patients discharged from the ED, especially when resources are limited.

SUMMARY

Antibiotic stewardship is a core component of ED practice and impacts patient safety, clinical outcomes, and public health. The unique characteristics of ED practice, including crowding, time pressure, and diagnostic uncertainty, need to be considered when implementing antibiotic stewardship interventions in this setting. Rapid advances in pathogen detection and host response biomarkers promise to revolutionize the diagnosis of ID in the ED, but such tests are not yet considered standard of care. At present, clinical decision support embedded in the electronic health record and pharmacist-led interventions are the two most effective ways to improve antibiotic prescribing in the ED.

DISCLOSURE

Dr J. Sapozhnikov is an employee of Karius, Inc. Drs F.S. Albarillo and M.S. Pulia have no relevant commercial or financial conflict of interest or funding sources related to this work.

REFERENCES

1. Centers for Disease Control and Prevention. About antibiotic resistance. Available at: 2022 https://www.cdc.gov/drugresistance/about.html. [Accessed 30 June 2023].
2. World Health Organization. Antimicrobial resistance. Available at: https://www.who.int/news-room/fact-sheets/detail/antimicrobial-resistance. [Accessed 30 June 2023].
3. Centers for Disease Control and Prevention, Antibiotic Resistance Threats in the United States 2019, Available at: https://www.cdc.gov/drugresistance/pdf/threats-report/2019-ar-threats-report-508.pdf. (Accessed 1 March 2024).
4. Morris AM, Bai A, Burry L, et al. Long-term effects of phased implementation of antimicrobial stewardship in academic ICUs: 2007-2015. Crit Care Med 2019; 47(2):159–66.
5. Yong MK, Buising KL, Cheng AC, et al. Improved susceptibility of gram-negative bacteria in an intensive care unit following implementation of a

Descargado para Dr Jorge Martel Granados (emergencymedicine.peru@gmail.com) en Pontifical Xavierian University de ClinicalKey.es por Elsevier en mayo 03, 2024. Para uso personal exclusivamente. No se permiten otros usos sin autorización. Copyright ©2024. Elsevier Inc. Todos los derechos reservados.

computerized antibiotic decision support system. J Antimicrob Chemother 2010;65(5):1062–9.
6. Dellit TH, Owens RC, McGowan JE Jr, et al. Infectious Diseases Society of America and the Society for Healthcare Epidemiology of America guidelines for developing an institutional program to enhance antimicrobial stewardship. Clin Infect Dis 2007;44(2):159–77.
7. Magill SS, Edwards JR, Beldavs ZG, et al. Prevalence of antimicrobial use in US acute care hospitals, May-September 2011. JAMA 2014;312(14):1438–46.
8. Hecker MT, Fox CJ, Son AH, et al. Effect of a stewardship intervention on adherence to uncomplicated cystitis and pyelonephritis guidelines in an emergency department setting. PLoS One 2014;9(2). https://doi.org/10.1371/journal.pone.0087899.
9. Valiquette L, Cossette B, Garant MP, et al. Impact of a reduction in the use of high-risk antibiotics on the course of an epidemic of *Clostridium difficile*-associated disease caused by the hypervirulent NAP1/027 strain. Clin Infect Dis 2007;45(Suppl 2):S112–21.
10. ACEP Antimicrobial Stewardship Policy Statement. Available at: https://www.acep.org/patient-care/policy-statements/antimicrobial-stewardship/. [Accessed 3 August 2020].
11. Gupta A, Petty L, Gandhi T, et al. Overdiagnosis of urinary tract infection linked to overdiagnosis of pneumonia: a multihospital cohort study. BMJ Qual Saf 2022;31(5):383–6.
12. Kooda K, Bellolio F, Dierkhising R, et al. Defining antibiotic inertia: application of a focused clinical scenario survey to illuminate a new target for antimicrobial stewardship during transitions of care. Clin Infect Dis 2022;74(11):2050–2.
13. Kiyatkin D, Bessman E, McKenzie R. Impact of antibiotic choices made in the emergency department on appropriateness of antibiotic treatment of urinary tract infections in hospitalized patients. J Hosp Med 2016;11(3):181–4.
14. May L, Gudger G, Armstrong P, et al. Multisite exploration of clinical decision making for antibiotic use by emergency medicine providers using quantitative and qualitative methods. Infect Control Hosp Epidemiol 2014;35(9):1114–25.
15. Pulia MS, Schwei RJ, Hesse SP, et al. Characterizing barriers to antibiotic stewardship for skin and soft-tissue infections in the emergency department using a systems engineering framework. Antimicrob Steward Healthc Epidemiol ASHE 2022;2(1):e180.
16. Valmadrid LC, Schwei RJ, Maginot E, et al. The impact of health care provider relationships and communication dynamics on urinary tract infection management and antibiotic utilization for long-term care facility residents treated in the emergency department: a qualitative study. Am J Infect Control 2021;49(2):198–205.
17. Chan YY, Bin Ibrahim MA, Wong CM, et al. Determinants of antibiotic prescribing for upper respiratory tract infections in an emergency department with good primary care access: a qualitative analysis. Epidemiol Infect 2019;147. https://doi.org/10.1017/S095026881800331X.
18. Goulopoulos A, Rofe O, Kong D, et al. Attitudes and beliefs of Australian emergency department clinicians on antimicrobial stewardship in the emergency department: a qualitative study. Emerg Med Australas EMA 2019;31(5):787–96.
19. Stefan MS, Spitzer KA, Zulfiqar S, et al. Uncertainty as a critical determinant of antibiotic prescribing in patients with an asthma exacerbation: a qualitative study. J Asthma 2022;59(2):352–61.

Descargado para Dr Jorge Martel Granados (emergencymedicine.peru@gmail.com) en Pontifical Xavierian University de ClinicalKey.es por Elsevier en mayo 03, 2024. Para uso personal exclusivamente. No se permiten otros usos sin autorización. Copyright ©2024. Elsevier Inc. Todos los derechos reservados.

20. Pulia MS, Hesse S, Schwei RJ, et al. Inappropriate antibiotic prescribing for respiratory conditions does not improve Press Ganey patient satisfaction scores in the emergency department. Open Forum Infect Dis 2020;7(6):ofaa214.
21. Ong S, Nakase J, Moran GJ, et al. Antibiotic use for emergency department patients with upper respiratory infections: prescribing practices, patient expectations, and patient satisfaction. Ann Emerg Med 2007;50(3):213–20.
22. Borde JP, Kern WV, Hug M, et al. Implementation of an intensified antibiotic stewardship programme targeting third-generation cephalosporin and fluoroquinolone use in an emergency medicine department. Emerg Med J 2015;32(7):509–15.
23. Ostrowsky B, Sharma S, DeFino M, et al. Antimicrobial stewardship and automated pharmacy technology improve antibiotic appropriateness for community-acquired pneumonia. Infect Control Hosp Epidemiol 2013;34(6):566–72.
24. Dinh A, Duran C, Davido B, et al. Impact of an antimicrobial stewardship programme to optimize antimicrobial use for outpatients at an emergency department. J Hosp Infect 2017;97(3):288–93.
25. Jorgensen SCJ, Yeung SL, Zurayk M, et al. Leveraging antimicrobial stewardship in the emergency department to improve the quality of urinary tract infection management and outcomes. Open Forum Infect Dis 2018;5(6). https://doi.org/10.1093/ofid/ofy101.
26. Randolph TC. Expansion of pharmacists' responsibilities in an emergency department. Am J Health Syst Pharm 2009;66(16):1484–7.
27. Pulia M, Redwood R, May L. Antimicrobial stewardship in the emergency department. Emerg Med Clin North Am 2018;36(4):853–72.
28. DeFrates SR, Weant KA, Seamon JP, et al. Emergency pharmacist impact on health care-associated pneumonia empiric therapy. J Pharm Pr 2013;26(2):125–30.
29. Acquisto NM, Baker SN. Antimicrobial stewardship in the emergency department. J Pharm Pr 2011;24(2):196–202.
30. Trinh TD, Klinker KP. Antimicrobial stewardship in the emergency department. Infect Ther 2015;4(Suppl 1):39–50.
31. Wymore ES, Casanova TJ, Broekemeier RL, et al. Clinical pharmacist's daily role in the emergency department of a community hospital. Am J Health-Syst Pharm AJHP 2008;65(5):395–6, 398-399.
32. Davis LC, Covey RB, Weston JS, et al. Pharmacist-driven antimicrobial optimization in the emergency department. Am J Health Syst Pharm 2016;73(5 Suppl 1):S49–56.
33. Moussavi K, Nikitenko V. Pharmacist impact on time to antibiotic administration in patients with sepsis in an ED. Am J Emerg Med 2016;34(11):2117–21.
34. Rech MA, Adams W, Smetana KS, et al. PHarmacist Avoidance or Reductions in Medical Costs in Patients Presenting the EMergency Department: PHARM-EM Study. Crit Care Explor 2021;3(4):e0406.
35. Kulwicki BD, Brandt KL, Wolf LM, et al. Impact of an emergency medicine pharmacist on empiric antibiotic prescribing for pneumonia and intra-abdominal infections. Am J Emerg Med 2019;37(5):839–44.
36. Weant KA, Baker SN. Emergency medicine pharmacists and sepsis management. J Pharm Pr 2013;26(4):401–5.
37. Faine BA, Mohr N, Dietrich J, et al. Antimicrobial therapy for pneumonia in the emergency department: the impact of clinical pharmacists on appropriateness. West J Emerg Med 2017;18(5):856–63.

Descargado para Dr Jorge Martel Granados (emergencymedicine.peru@gmail.com) en Pontifical Xavierian University de ClinicalKey.es por Elsevier en mayo 03, 2024. Para uso personal exclusivamente. No se permiten otros usos sin autorización. Copyright ©2024. Elsevier Inc. Todos los derechos reservados.

38. Lingenfelter E, Drapkin Z, Fritz K, et al. ED pharmacist monitoring of provider antibiotic selection aids appropriate treatment for outpatient UTI. Am J Emerg Med 2016;34(8):1600–3.
39. Harvey S, Brad Hall A, Wilson K. Impact of an emergency medicine pharmacist on initial antibiotic prophylaxis for open fractures in trauma patients. Am J Emerg Med 2018;36(2):290–3.
40. Kooda K, Canterbury E, Bellolio F. Impact of pharmacist-led antimicrobial stewardship on appropriate antibiotic prescribing in the emergency department: a systematic review and meta-analysis. Ann Emerg Med 2022;79(4):374–87.
41. Evans L, Rhodes A, Alhazzani W, et al. Surviving Sepsis Campaign: international guidelines for management of sepsis and septic shock 2021. Crit Care Med 2021;49(11):e1063–143.
42. Flynn JD, McConeghy KW, Flannery AH, et al. Utilization of pharmacist responders as a component of a multidisciplinary sepsis bundle. Ann Pharmacother 2014;48(9):1145–51.
43. Hunt A, Nakajima S, Hall Zimmerman L, et al. Impact of prospective verification of intravenous antibiotics in an ED. Am J Emerg Med 2016. https://doi.org/10.1016/j.ajem.2016.09.004.
44. Campbell S, Hauler G, Immler EL, et al. Pharmacist-led penicillin allergy assessment in the emergency department reduced empiric fluoroquinolone use. Clin Infect Dis 2020;71(9):e506–8.
45. Alqurashi W, Saux NL, Vyles D, et al. De-labelling penicillin allergy in the emergency department. J Allergy Clin Immunol 2023;151(2):AB66.
46. May L, Cosgrove S, L'Archeveque M, et al. A call to action for antimicrobial stewardship in the emergency department: approaches and strategies. Ann Emerg Med 2013;62(1):69–77.e2.
47. DeWitt KM, Weiss SJ, Rankin S, et al. Impact of an emergency medicine pharmacist on antibiotic dosing adjustment. Am J Emerg Med 2016;34(6):980–4.
48. Baker SN, Acquisto NM, Ashley ED, et al. Pharmacist-managed antimicrobial stewardship program for patients discharged from the emergency department. J Pharm Pr 2012;25(2):190–4.
49. Cohen V, Jellinek SP, Hatch A, et al. Effect of clinical pharmacists on care in the emergency department: a systematic review. Am J Health-Syst Pharm AJHP 2009;66(15):1353–61.
50. Seitz RM, Wiley Z, Francois CF, et al. Improved empiric antibiotic prescribing for common infectious disease diagnoses using order sets with built-in clinical decision support in the emergency department. Infect Control Hosp Epidemiol 2021;1–2. https://doi.org/10.1017/ice.2021.73.
51. Vuong L, Kenney RM, Thomson JM, et al. Implementation of indication-based antibiotic order sentences improves antibiotic use in emergency departments. Am J Emerg Med 2023. https://doi.org/10.1016/j.ajem.2023.03.048.
52. Peyko V, Daves A, Eggleston M. Comparing an emergency department–specific antibiogram versus hospital-wide antibiogram and therapeutic dilemmas for uncomplicated cystitis. Infect Dis Clin Pract 2019;27(3):155–9.
53. Zatorski C, Jordan JA, Cosgrove SE, et al. Comparison of antibiotic susceptibility of *Escherichia coli* in urinary isolates from an emergency department with other institutional susceptibility data. Am J Health-Syst Pharm AJHP 2015;72(24):2176–80.
54. Hudepohl NJ, Cunha CB, Mermel LA. Antibiotic prescribing for urinary tract infections in the emergency department based on local antibiotic resistance

Descargado para Dr Jorge Martel Granados (emergencymedicine.peru@gmail.com) en Pontifical Xavierian University de ClinicalKey.es por Elsevier en mayo 03, 2024. Para uso personal exclusivamente. No se permiten otros usos sin autorización. Copyright ©2024. Elsevier Inc. Todos los derechos reservados.

patterns: implications for antimicrobial stewardship. Infect Control Hosp Epidemiol 2016;37(3):359–60.
55. Smith SC, Bazzoli C, Chung I, et al. Antimicrobial susceptibility of *Escherichia coli* in uncomplicated cystitis in the emergency department: is the hospital antibiogram an effective treatment guide? Acad Emerg Med 2015;22(8):998–1000.
56. Jorgensen S, Zurayk M, Yeung S, et al. Emergency department urinary antibiograms differ by specific patient group. J Clin Microbiol 2017;55(9):2629–36.
57. Rosa R, Abbo LM, Raney K, et al. Antimicrobial resistance in urinary tract infections at a large urban ED: factors contributing to empiric treatment failure. Am J Emerg Med 2017;35(3):397–401.
58. Fleming VH, White BP, Southwood R. Resistance of *Escherichia coli* urinary isolates in ED-treated patients from a community hospital. Am J Emerg Med 2014;32(8):864–70.
59. Demonchy E, Dufour JC, Gaudart J, et al. Impact of a computerized decision support system on compliance with guidelines on antibiotics prescribed for urinary tract infections in emergency departments: a multicentre prospective before-and-after controlled interventional study. J Antimicrob Chemother 2014;69(10):2857–63.
60. Gonzales R, Anderer T, McCulloch CE, et al. A cluster randomized trial of decision support strategies for reducing antibiotic use in acute bronchitis. JAMA Intern Med 2013;173(4):267–73.
61. Dean NC, Jones BE, Jones JP, et al. Impact of an electronic clinical decision support tool for emergency department patients with pneumonia. Ann Emerg Med 2015;66(5):511–20.
62. Satterfield J, Miesner AR, Percival KM. The role of education in antimicrobial stewardship. J Hosp Infect 2020;105(2):130–41.
63. Percival KM, Valenti KM, Schmittling SE, et al. Impact of an antimicrobial stewardship intervention on urinary tract infection treatment in the ED. Am J Emerg Med 2015;33(9):1129–33.
64. Flottorp S, Oxman AD, Håvelsrud K, et al. Cluster randomised controlled trial of tailored interventions to improve the management of urinary tract infections in women and sore throat. BMJ 2002;325(7360):367.
65. Hecker MT, Son AH, Murphy NN, et al. Impact of syndrome-specific antimicrobial stewardship interventions on use of and resistance to fluoroquinolones: an interrupted time series analysis. Am J Infect Control 2019;47(8):869–75.
66. Stoll K, Feltz E, Ebert S. Pharmacist-driven implementation of outpatient antibiotic prescribing algorithms improves guideline adherence in the emergency department. J Pharm Pract 2021;34(6):875–81.
67. Barlam TF, Cosgrove SE, Abbo LM, et al. Implementing an antibiotic stewardship program: guidelines by the Infectious Diseases Society of America and the Society for Healthcare Epidemiology of America. Clin Infect Dis 2016;62(10):e51–77.
68. Albarillo FS, Labuszewski L, Lopez J, et al. Use of a clinical decision support system (CDSS) to improve antimicrobial stewardship efforts at a single academic medical center. Germs 2019;9(2):106–9.
69. Harrington N, Sierzenski P, Taylor K, et al. Enhancing antimicrobial stewardship for pneumonia in the emergency department utilizing a clinical decision support tool. Open Forum Infect Dis 2015;2(suppl_1):1431.
70. Hajesmaeel-Gohari S, Bahaadinbeigy K, Tajoddini S, et al. Effect of computerized physician order entry and clinical decision support system on adverse

Descargado para Dr Jorge Martel Granados (emergencymedicine.peru@gmail.com) en Pontifical Xavierian University de ClinicalKey.es por Elsevier en mayo 03, 2024. Para uso personal exclusivamente. No se permiten otros usos sin autorización. Copyright ©2024. Elsevier Inc. Todos los derechos reservados.

drug events prevention in the emergency department: a systematic review. J Pharm Technol JPT 2021;37(1):53–61.
71. Morgan DJ, Malani P, Diekema DJ. Diagnostic stewardship—leveraging the laboratory to improve antimicrobial use. JAMA 2017;318(7):607.
72. Claeys KC, Johnson MD. Leveraging diagnostic stewardship within antimicrobial stewardship programmes. Drugs Context 2023;12. 2022-2029-5.
73. Zakhour J, Haddad SF, Kerbage A, et al. Diagnostic stewardship in infectious diseases: a continuum of antimicrobial stewardship in the fight against antimicrobial resistance. Int J Antimicrob Agents 2023;62(1):106816.
74. Goebel MC, Trautner BW, Grigoryan L. The five Ds of outpatient antibiotic stewardship for urinary tract infections. Clin Microbiol Rev 2021;34(4):e0000320.
75. Cooper RJ, Hoffman JR, Bartlett JG, et al. Principles of appropriate antibiotic use for acute pharyngitis in adults: background. Ann Intern Med 2001;134(6):509–17.
76. Stone S, Gonzales R, Maselli J, et al. Antibiotic prescribing for patients with colds, upper respiratory tract infections, and bronchitis: a national study of hospital-based emergency departments. Ann Emerg Med 2000;36(4):320–7.
77. Rao A, Berg B, Quezada T, et al. Diagnosis and antibiotic treatment of group a streptococcal pharyngitis in children in a primary care setting: impact of point-of-care polymerase chain reaction. BMC Pediatr 2019;19(1):24.
78. Orda U, Mitra B, Orda S, et al. Point of care testing for group A streptococci in patients presenting with pharyngitis will improve appropriate antibiotic prescription. Emerg Med Australas 2016;28(2):199–204.
79. Cardoso DM, Gilio AE, Hsin SH, et al. Impact of the rapid antigen detection test in diagnosis and treatment of acute pharyngotonsillitis in a pediatric emergency room. Rev Paul Pediatr 2013;31(1):4–9.
80. Clark TW, jo Medina M, Batham S, et al. Adults hospitalised with acute respiratory illness rarely have detectable bacteria in the absence of COPD or pneumonia; viral infection predominates in a large prospective UK sample. J Infect 2014;69(5):507–15.
81. Papi A, Bellettato CM, Braccioni F, et al. Infections and airway inflammation in chronic obstructive pulmonary disease severe exacerbations. Am J Respir Crit Care Med 2006;173(10):1114–21.
82. Bouzid D, Zanella MC, Kerneis S, et al. Rapid diagnostic tests for infectious diseases in the emergency department. Clin Microbiol Infect 2021;27(2):182–91.
83. Shoar S, Musher DM. Etiology of community-acquired pneumonia in adults: a systematic review. Pneumonia 2020;12(1):11.
84. Lee JJ, Verbakel JY, Goyder CR, et al. The clinical utility of point-of-care tests for influenza in ambulatory care: a systematic review and meta-analysis. Clin Infect Dis 2019;69(1):24–33.
85. Stamm BD, Tamerius J, Reddy S, et al. The influence of rapid influenza diagnostic testing on clinician decision-making for patients with acute respiratory infection in urgent care. Clin Infect Dis 2023;76(11):1942–8.
86. Rappo U, Schuetz AN, Jenkins SG, et al. Impact of early detection of respiratory viruses by multiplex PCR assay on clinical outcomes in adult patients. J Clin Microbiol 2016;54(8):2096–103.
87. Buchan BW, Windham S, Balada-Llasat JM, et al. Practical comparison of the BioFire FilmArray pneumonia panel to routine diagnostic methods and potential impact on antimicrobial stewardship in adult hospitalized patients with lower respiratory tract infections. J Clin Microbiol 2020;58(7). e00135-20.

Descargado para Dr Jorge Martel Granados (emergencymedicine.peru@gmail.com) en Pontifical Xavierian University de ClinicalKey.es por Elsevier en mayo 03, 2024. Para uso personal exclusivamente. No se permiten otros usos sin autorización. Copyright ©2024. Elsevier Inc. Todos los derechos reservados.

88. May L, Dissen E, Smith M, et al. Clinical decisionmaking and antibiotic use in patients with abscesses after rapid point-of-care MRSA/MSSA testing in the emergency department. Ann Emerg Med 2011;58(4):S292–3.
89. Beal SG, Tremblay EE, Toffel S, et al. A gastrointestinal PCR panel improves clinical management and lowers health care costs. J Clin Microbiol 2018;56(1). 014577-17.
90. Ena J, Afonso-Carrillo RG, Bou-Collado M, et al. Evaluation of FilmArray ME panel for the rapid diagnosis of meningitis-encephalitis in emergency departments. Intern Emerg Med 2021;16(5):1289–95.
91. Metlay JP, Waterer GW, Long AC, et al. Diagnosis and treatment of adults with community-acquired pneumonia. An official clinical practice guideline of the American Thoracic Society and Infectious Diseases Society of America. Am J Respir Crit Care Med 2019;200(7):e45–67.
92. Self WH, Balk RA, Grijalva CG, et al. Procalcitonin as a marker of etiology in adults hospitalized with community-acquired pneumonia. Clin Infect Dis 2017; 65(2):183–90.
93. IDSA Community-Acquired Pneumonia (CAP) Clinical Pathway Algorithm. Available at: https://www.idsociety.org/globalassets/idsa/practice-guidelines/community-acquired-pneumonia-in-adults/cap-clinical-pathway-overview.pdf. [Accessed 1 February 2024].
94. Pulia MS, Lindenauer PK. Annals for hospitalists inpatient notes: a critical look at procalcitonin testing in pneumonia. Ann Intern Med 2021;174(6). HO2-HO3.
95. Tsalik EL, Rouphael NG, Sadikot RT, et al. Efficacy and safety of azithromycin versus placebo to treat lower respiratory tract infections associated with low procalcitonin: a randomised, placebo-controlled, double-blind, non-inferiority trial. Lancet Infect Dis 2023;23(4):484–95.
96. Atallah J, Mansour MK. Implications of using host response-based molecular diagnostics on the management of bacterial and viral infections: a review. Front Med 2022;9:805107.
97. Klein A, Shapira M, Lipman-Arens S, et al. Diagnostic accuracy of a real-time host-protein test for infection. Pediatrics 2023;e2022060441. https://doi.org/10.1542/peds.2022-060441.
98. Shapiro NI, Filbin MR, Hou PC, et al. Diagnostic accuracy of a bacterial and viral biomarker point-of-care test in the outpatient setting. JAMA Netw Open 2022; 5(10):e2234588.
99. O'Neal HRJ, Sheybani R, Caffery TS, et al. Assessment of a cellular host response test as a sepsis diagnostic for those with suspected infection in the emergency department. Crit Care Explor 2021;3(6):e0460.
100. Claeys KC, Blanco N, Morgan DJ, et al. Advances and challenges in the diagnosis and treatment of urinary tract infections: the need for diagnostic stewardship. Curr Infect Dis Rep 2019;21(4):11.
101. Chironda B, Clancy S, Powis JE. Optimizing urine culture collection in the emergency department using frontline ownership interventions. Clin Infect Dis 2014; 59(7):1038–9.
102. Stagg A, Lutz H, Kirpalaney S, et al. Impact of two-step urine culture ordering in the emergency department: a time series analysis. BMJ Qual Saf 2018;27(2): 140–7.
103. Dietz J, Lo TS, Hammer K, et al. Impact of eliminating reflex urine cultures on performed urine cultures and antibiotic use. Am J Infect Control 2016;44(12): 1750–1.

Descargado para Dr Jorge Martel Granados (emergencymedicine.peru@gmail.com) en Pontifical Xavierian University de ClinicalKey.es por Elsevier en mayo 03, 2024. Para uso personal exclusivamente. No se permiten otros usos sin autorización. Copyright ©2024. Elsevier Inc. Todos los derechos reservados.

104. Jaeger C, Waymack J, Sullivan P, et al. Refining reflex urine culture testing in the ED. Am J Emerg Med 2019;37(7):1380–2.
105. Coughlin RF, Peaper D, Rothenberg C, et al. Electronic health record-assisted reflex urine culture testing improves emergency department diagnostic efficiency. Am J Med Qual 2020;35(3):252–7.
106. Cunney R, Aziz HA, Schubert D, et al. Interpretative reporting and selective antimicrobial susceptibility release in non-critical microbiology results. J Antimicrob Chemother 2000;45(5):705–8.
107. Daley P, Garcia D, Inayatullah R, et al. Modified reporting of positive urine cultures to reduce inappropriate treatment of asymptomatic bacteriuria among nonpregnant, noncatheterized inpatients: a randomized controlled trial. Infect Control Hosp Epidemiol 2018;39(7):814–9.
108. Fleming-Dutra KE, Hersh AL, Shapiro DJ, et al. Prevalence of inappropriate antibiotic prescriptions among US ambulatory care visits, 2010-2011. JAMA 2016; 315(17):1864–73.
109. Wu JY, Balmat R, Kahle ML, et al. Evaluation of a health system-wide pharmacist-driven emergency department laboratory follow-up and antimicrobial management program. Am J Emerg Med 2020;38(12):2591–5.
110. Dumkow LE, Kenney RM, MacDonald NC, et al. Impact of a multidisciplinary culture follow-up program of antimicrobial therapy in the emergency department. Infect Ther 2014;3(1):45–53.
111. Shealy SC, Alexander C, Hardison TG, et al. Pharmacist-driven culture and sexually transmitted infection testing follow-up program in the emergency department. Pharm Basel Switz 2020;8(2):72.
112. Almulhim AS, Aldayyen A, Yenina K, et al. Optimization of antibiotic selection in the emergency department for urine culture follow ups, a retrospective pre-post intervention study: clinical pharmacist efforts. J Pharm Policy Pract 2019;12:8.
113. Miller K, McGraw MA, Tomsey A, et al. Pharmacist addition to the post-ED visit review of discharge antimicrobial regimens. Am J Emerg Med 2014;32(10): 1270–4.
114. Randolph TC, Parker A, Meyer L, et al. Effect of a pharmacist-managed culture review process on antimicrobial therapy in an emergency department. Am J Health Syst Pharm 2011;68(10):916–9.
115. Olson A, Feih J, Feldman R, et al. Involvement of pharmacist-reviewed urine cultures and sexually transmitted infections in the emergency department reduces time to antimicrobial optimization. Am J Health-Syst Pharm AJHP 2020; 77(Supplement_2):S54–8.
116. Rainess RA, Patel VV, Cavanaugh JB, et al. Evaluating the addition of a clinical pharmacist service to a midlevel provider-driven culture follow-up program in a community emergency department. J Pharm Technol JPT 2021;37(3):140–6.
117. Bao H, Dubrovskaya Y, Jen SP, et al. Novel multidisciplinary approach for outpatient antimicrobial stewardship using an emergency department follow-up program. J Pharm Pract 2023;36(2):329–35.

Descargado para Dr Jorge Martel Granados (emergencymedicine.peru@gmail.com) en Pontifical Xavierian University de ClinicalKey.es por Elsevier en mayo 03, 2024. Para uso personal exclusivamente. No se permiten otros usos sin autorización. Copyright ©2024. Elsevier Inc. Todos los derechos reservados.